Why has Safety Improved at Rail-Highway Grade Crossings?

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Two papers:


Motor Vehicle Incidents and Fatalities at Public Crossings
Many Possible Explanations:

- Crossing closures
- Active Warning Devices installed
- Public education campaign
- Ditch lights installed
- Highway safety in general has improved
- But, rail traffic has increased
- And, highway traffic has substantially increased

Most of these effects are highly correlated
Regression analysis required:

- Macro level analysis – very different from “micro” analysis of individual crossings
- Incidents involving *motor vehicles* at *public crossings*
- Initial analysis will use annual data for 49 states (no HI, DC) from 1975 to 2001
- FRA/FHWA data
- Negative binomial regression
Regression analysis:

• Two regressions:
  - number of incidents
  - fatalities in these incidents

• Exposure variable
  - Number of Crossings
Functional Form:

\[ \text{Count of incidents/fatalities} = e^{(\beta \ln \text{crossings} + \gamma \ln \text{other variables})} + \varepsilon \]
Explanatory Variables in Logs:

- Highway traffic (state non-Interstate highway AADT)
- State average daily trains per crossing
- Proportion of crossings with active warning devices in state
- State highway fatal crash (or fatality) rate elsewhere on highway system
Other Explanatory Variables:

• Dummy variable = 1 if *Operation Lifesaver* is active in state (it spread across the nation between 1972 and 1986)

• Proportion of locomotives fitted with “ditch lights.” Assumed fitted at constant rate between September 1995 (announcement of rule) and December 1997

• State dummy variables (with Georgia as “base” state)
## Incidents: 10,971 (1975) to 2,695 (2001)

<table>
<thead>
<tr>
<th>Change in Annual Incidents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Closures</td>
<td>-1040</td>
</tr>
<tr>
<td>Increased Highway Traffic</td>
<td>89</td>
</tr>
<tr>
<td>Increased Train Traffic</td>
<td>556</td>
</tr>
<tr>
<td>Increased Lights/Gates</td>
<td>-1786</td>
</tr>
<tr>
<td>General Highway Safety Improvement</td>
<td>-3913</td>
</tr>
<tr>
<td>Operation Lifesaver</td>
<td>-1455</td>
</tr>
<tr>
<td>Ditch Lights</td>
<td>-1279</td>
</tr>
<tr>
<td>Cross-product Terms</td>
<td>259</td>
</tr>
<tr>
<td>Not Explained</td>
<td>294</td>
</tr>
</tbody>
</table>
## Fatalities: 786 (1975) to 315 (2001)

<table>
<thead>
<tr>
<th>Change in Annual Fatalities</th>
<th>(471)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Closures</td>
<td>(60)</td>
</tr>
<tr>
<td>Increased Highway Traffic</td>
<td>201</td>
</tr>
<tr>
<td>Increased Train Traffic</td>
<td>157</td>
</tr>
<tr>
<td>Increased Lights/Gates</td>
<td>(115)</td>
</tr>
<tr>
<td>General Highway Safety Improvement</td>
<td>(305)</td>
</tr>
<tr>
<td>Operation Lifesaver</td>
<td>(164)</td>
</tr>
<tr>
<td>Ditch Lights</td>
<td>(268)</td>
</tr>
<tr>
<td>Cross-product Terms</td>
<td>(12)</td>
</tr>
<tr>
<td>Not Explained</td>
<td>95</td>
</tr>
</tbody>
</table>
HR Incidents: Actual versus Predicted

![Graph showing HR Incidents from 1975 to 2000, comparing actual and predicted values.](image_url)
HR Fatalities: Actual versus Predicted

The graph shows the comparison of actual HR fatalities against predicted values from 1975 to 2000. The actual data points are represented by diamonds, while the predicted trend is shown as a line. The fatalities trend has been decreasing over the years, with a notable decline from 1995 onwards.
Discussion:

• General safety improvements on highways dominate
• Ditch lights appear to be very effective. Incidents down 29%, fatalities by 44%. But other initiatives occurred at the same time?
• Installation of active warning devices is effective
Discussion – Section 130:

- Expenditure 1975 to 2001: $8.5bn at current prices – a capital expenditure, plus additional annual maintenance
- 1,746 incidents and 115 lives saved each year over life of equipment
- Cost-benefit analysis over 30 years at 7% discount rate
- Valuation of lives and injuries at standard DOT/FRA levels prevailing before 2008
- Time saving from not having to slow down and look for a train
### Discussion - Section 130:

<table>
<thead>
<tr>
<th></th>
<th>PV $m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Fatalities</td>
<td>4,582</td>
</tr>
<tr>
<td>Reduced Serious Injuries</td>
<td>7,453</td>
</tr>
<tr>
<td>Reduced Moderate Injuries</td>
<td>154</td>
</tr>
<tr>
<td>Reduced Property Damage</td>
<td>321</td>
</tr>
<tr>
<td>Time Saving</td>
<td>6,199</td>
</tr>
<tr>
<td><strong>Total Benefits</strong></td>
<td><strong>18,710</strong></td>
</tr>
<tr>
<td>Section 130 Expenditures</td>
<td>(8,475)</td>
</tr>
<tr>
<td>Additional Maintenance</td>
<td>(557)</td>
</tr>
<tr>
<td><strong>Benefit-Cost Ratio</strong></td>
<td>2.07</td>
</tr>
</tbody>
</table>
Discussion – *Operation Lifesaver*:

- Introducing *Operation Lifesaver* reduces incidents by 15%, fatalities by 19%
- Regression is multiplicative
- Risk was much higher, in general, when the programs started (1972-1986) compared with today
Indiana HR Incidents: Actual versus Predicted
Operation Lifesaver Active From 1980
Discussion – *Operation Lifesaver*:

- Initial implementation saved 1,455 incidents and 164 lives per year
- If *Operation Lifesaver* ceased today, when risk is lower, 500 additional incidents and 75 extra fatalities per year
- Compare with the annual cost of *Operation Lifesaver* of less than $6 million
Further Analysis of *Operation Lifesaver*:

- Initial analysis (Mok and Savage, 2005) had:
  - data on 49 states from 1975 to 2001
  - existence of *Operation Lifesaver* in state represented by a 0-1 dummy variable

- Follow-up paper (Savage, 2006) has:
  - data on 46 states from 1996 to 2002
  - *Operation Lifesaver* activity in a state represented by number of presentations and special training events per 1,000 crossings
Annual Incidents and OL Presentations per 1000 Crossings by State 1996-2002

Rate of Incidents

Rate of Presentations and Special Training

Historically High Risk
Historically Average Risk
Historically Low Risk
Further Analysis of *Operation Lifesaver*:

- Activity varies markedly between states, and between years for some states
- *Operation Lifesaver* assisted in cleaning up data:
  - 3 States (AZ, MA, VA) dropped entirely
  - 14 observations from 11 states missing
  - 16 observations from 9 states questionable
  - 292 out of possible 343 observations used
- Other variables the same as the original analysis
Further Analysis of *Operation Lifesaver*:

• Point elasticity between *Operation Lifesaver* activity in a state and number of incidents is -0.11

• Effect on number of fatalities statistically indeterminate – deaths are quite rare and concentrated in only a few states making analysis difficult
In Conclusion:

- Risk has reduced considerably despite increased rail and highway traffic
- Backdrop of improved highway safety in general
- Engineering is important – Section 130 and Ditch Lights
- So is education – *Operation Lifesaver*. Findings consistent with NCHRP Report 470 (2002) which found public confusion regarding crossing signage and conduct
- ...if only we had some more data on enforcement
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• Read the papers at:
  http://faculty.wcas.northwestern.edu/~ipsavage/rail.html